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ABSTRACT

This paper examines two major questions regarding the use of manipulatives in teaching and learning mathematics in the elementary school. First, what does recent research indicate about this topic? It was found that research predominately favors the use of manipulatives with strong support for the use of appropriate kinds of manipulatives for the beginning phases of learning new concepts. Second, what is the extent of availability and usage of manipulatives in grades K through 3? A survey was completed of 75 primary teachers in 11 Southern California schools regarding four types of manipulatives. More than 70% of the schools had available unifix cubes and Cuisenaire rods, while less than 46% had abacuses and base 10 blocks. In terms of frequency of use, teachers of grades K through 3 reported a usage of "some" and "often" of 75% for unifix cubes, 40% for Cuisenaire rods, 19% for abacuses, and 29% for base 10 blocks. Four recommendations for clarifying the role of manipulative materials are included. (Author/MNS)

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USING SELECTED MANIPULATIVE MATERIALS IN TEACHING MATHEMATICS IN THE PRIMARY GRADES

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ABSTRACT

This paper examines two major questions regarding the use of manipulatives in teaching and learning mathematics in the elementary school. First, what does recent research indicate about this topic. It was found that research predominately favors the use of manipulatives with strong support for the use of appropriate kinds of manipulatives for the beginning phases of learning new concepts. Second, what is the extent of availability and usage of manipulatives in grades K through 3? A survey was completed of 75 primary teachers in 11 Southern California schools regarding four types of manipulatives. More than 70% of the schools had available unifix cubes and Cuisenaire rods, while less than 46% had abacuses and base ten blocks. In terms of frequency of use, teachers of grades K through 3 reported a usage of "some" and "often" of 75% for unifix cubes, 40% for Cuisenaire rods, 19% for abacuses, and 29% for base ten blocks.

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USING SELECTED MANIPULATIVE MATERIALS IN TEACHING MATHEMATICS IN THE PRIMARY GRADES

INTRODUCTION

During the last half century many changes have taken place in the teaching of elementary mathematics. As a result, several basic principles have been introduced that have survived throughout the years. Two of these principles, now universally accepted by leading authorities in mathematics education, are: (1) The child should understand what is learned, and (2) Pupils should have the opportunity to manipulate materials to help them discover a concept or procedure.

The purpose of this paper is to consider two major questions:

(1) What does recent research say about the value of manipulatives in teaching mathematics?

(2) What is the extent of classroom usage of selected manipulatives in the primary grades?

SELECTED FINDINGS OF RECENT RESEARCH STUDIES

Suydam and Weaver (1975) reviewed research on the role of manipulative materials in teaching elementary mathematics and concluded that ". . . much evidence has been cited which indicates that the use of concrete materials appeared to be essential in providing a firm foundation for developing mathematical ideas, concepts and skills. . ."[1]

Recent research generally supports the use of manipulatives in teaching elementary mathematics. Parham[2] performed a meta-analysis of 64 studies and compared the use and nonuse of manipulative materials on student achievement. He calculated 171 effect sizes and found that students using manipulatives scored on achievement tests at approximately the 85th percentile, while the non-users scored at about the 50th percentile. He concluded that manipulative materials do have a positive effect on student achievement in mathematics.

Historically there has been a generally accepted sequence of three levels as appropriate for teaching concepts in elementary mathematics: (1) start at the concrete or enactive level where the pupil manipulatives objects, (2) move to the semi-concrete, pictorial or iconic level where pupils draw or study drawings of mathematical situations and actions, and (3) conclude with the symbolic level where children learn to record ideas and actions with mathematical symbols and signs.

Olley[3] studied the effects of changing the sequence of levels and found that the least effective program was the one in which pupils learn only at the symbolic level. Protocols using "hands-on" manipulatives were preferable to a no-device protocol in facilitating an ability to verbalize rational responses to transfer tasks.

Baker[4] taught a group of beginning first graders six lessons of 60 minutes each on place value through a three level sequence of: (1) concrete, (2) iconic (pictures), and (3) symbolic. Another group of first graders were taught

through a two level sequence from iconic to symbolic. A third group was taught at the symbolic level only. She found that on mean scores of a place value post test, the achievement of all pupils taught by both the three level sequence and the two level sequence scored significantly higher than did the control group. The third group taught at the symbolic level did not differ significantly from the control group.

Punn[5] used the same sequence as Baker in teaching the multiplication facts. The results supplemented the findings of Baker.

Wheeler[6] compared solving two-digit addition and subtraction examples using four isomorpic concrete embodiments with solving the same examples in the symbolic mode. The concrete embodiments used were: (1) abacus, (2) bundling sticks, (3) place-value chart, and (4) multi-base blocks. He found that pupils who were proficient in regrouping on three or four embodiments scored significantly higher on the multi-digit written tests than children not proficient in using concrete materials. Pupils who used three or more enbodiments processed a significantly higher level of understanding of the regrouping concepts than pupils without proficiency with concrete aids.

The research studies reported here overwhelmingly favor the use of manipulatives for teaching mathematics. However, there remains the question of whether or not manipulaives are actually being used by teachers in helping children learn mathematics.

CLASSROOM USAGE OF MANIPULATIVES

In 1981, the National Society for the Study of Education published Selected Issues in Mathematics Education. Chapter 8, "The Role of Manipulative Materials in Learning of Mathematical Concepts," pointed out that ". . .

between the use of manipulative materials and students' achievement in the mathematics classroom ". . . it is perplexing that relatively few programs incorporate a substantive experimental component while so many others concentrate merely on completing the pages in the ubiquitous commercially produced textbooks and workbooks."[7]

Is this statement really true? To help answer this question we decided to conduct a survey of primary teachers in a relatively large school district in Southern California to determine the availability and use of selected manipulative materials for teaching mathematics in the primary grades. Specifically, primary teachers were asked about four types of materials: (1) base ten blocks, (2) Cuisenaire rods, (3) unifix cubes, and (4) abacuses.

Eleven schools out of 56 were selected at random from within the district. Questionnaires were sent to two teachers at each grade level from kindergarten through grade three. Of the 88 questionnaires distributed, 75 or 85 percent were returned.

The primary teachers reported a strong support for manipulatives materials in primary mathematics, with 79 percent (59) rating their use as essential and the remaining 21 percent (16) rating their use as desirable. Ninety-two

percent (69) indicated they used some type of manipulative material at some time when teaching number skills to young children.

KINDS OF MANIPULATIVES AVAILABLE IN THE SCHOOLS

Table 1 shows that of the four types of manipulatives listed on the questionnaire, the most frequently available in the schools were unifix cubes, with 92 percent (69) of the teachers reporting their availability. Base ten blocks and abacuses were reported available by only 45 percent (34) of the teachers for each type of aid. These two types of materials were more available in grades two and three than in grades K and 1. It is interesting to note that all kindergarten teachers reported that unifix cubes were available.

TABLE 1

MANIPULATIVES AVAILABLE IN THE SCHOOLS

	K	1	2	3	TOTAL
RESPONDENTS	19	22	21	13	75
UNIFIX CUBES	19(100%)	20(91%)	19(90%)	11(85%)	69(92%)
CUISENAIRES	11(58%)	13(59%)	19(90%)	10(77%)	53(71%)
ABACUSES	8(42%)	8(36%)	9(43%)	9(69%)	34(45%)
BASE TEN BLOCKS	5(26%)	7(32%)	10(48%)	12(92%)	34(45%)

FREQUENCY OF USAGE

Teachers who participated in this study were asked to estimate the extent of this usage of the manipulatives on a four-category basis: <u>often</u>, <u>some</u>, <u>seldom</u> and <u>not used</u>.

Table 2 gives the results of the materials given in Table 1. The abacus and base ten blocks were the least used of the four aids--each was not used by 63 percent of the teachers.

TABLE 2

FREQUENCY MANIPULATIVES ARE USED

	Kdg	First	Second	Third	TOTAL
RESPONDENTS	19	22	21	13	75
UNIFIX CUBES					
Often	16(84%)	10(45%)	4(19%)	2(15%)	32(43%)
Some	3(16%)	8(36%)	11(52%)	2(15%)	24(32%)
Seldom	0	2(9%)	1(5%)	5(38%)	8(11%)
Not used	0	2(9%)	5(24%)	7(54%)	14(19%)
CUISENAIRES					
Often	2(11%)	1(5%)	2(10%)	0	5(7%)
Some	8(42%)	4(18%)	9(43%)	3(23%)	25(33%)
Seldom	0	6(27%)	5(24%)	5(38%)	16(21%)
Not used	9(47%)	11(50%)	5(24%)	5(38%)	30(40%)
MODERN ABACUS					
Often	2(11%)	4(18%)	2(10%)	1(8%)	9(12%)
Some	2(11%)	0	1(5%)	2(15%)	5(7%)
Seldom	2(11%)	3(14%)	4(19%)	5(38%)	14(19%)
Not used	13(68%)	15(68%)	14(67%)	5(38%)	47(63%)
BASE TEN BLOCKS					
Often	0	1(5%)	3(14%)	3(23%)	7(9%)
Some	4(21%)	2(9%)	5(24%)	4(31%)	15(20%)
Seldom	3(16%)	5(23%)	3(14%)	4(31%)	15(20%)
Not used	12(63%)	14(64%)	10(48%)	11(85%)	47(63%)

Unifix cubes were the most frequently used aid, with 75 percent (56) of the teachers reporting they used them either some of the time or often. Cuisenaire rods were used some of the time by 33 percent (25) of the teachers and often by 7 percent (5) of the teachers.

The column on the right of Table 2 gives the frequency of use of each aid. Only unifix cubes were <u>often</u> used by the 75 teachers sampled and at least 30 percent of them did <u>not use</u> the remaining three teaching aids. On the other hand, all 75 teacher reported that some types of manipulative materials were used by pupils in some way at some time during lessons in mathematics.

Scott[8] made a study of usage of manipulatives for teaching mathematics as reported by teachers in 66 different elementary schools. These teachers reported 18 different kinds of manipulatives were used in the classrooms. The writers compared the results with the results from our investigation of the four aids we have used. Table 3 gives the comparison of usage. The numerals in parentheses give the percents for our study.

TABLE 3

COMPARISON OF USAGE OF MANIPULATIVES IN TWO STUDIES

	K	1	2	3
Unifix Cubes	36% (100)	17% (91)	12% (76)	12% (46)
Cuisenaire rods	91% (53)	57% (50)	48% (76)	41% (62)
Abacus	56% (32)	43% (32)	32% (33)	31% (62)
Base Ten	22% (37)	23% (36)	22% (52)	21% (15)

Note that the data given with the percent sign are from Scott's study and the data in parenthesis are from ours. Scott's study shows that Cuisenaire rods were the most widely used aid, in kindergarten whereas in our study unifix cubes were widely used. This usage is much greater than in our study. Unifix cubes were used sparingly in Scott's study in grades 1 through 3 compared with the extensive usage of these materials in our study. The abacus was used more widely in the study by Scott than in our study except at the third grade level. Base ten blocks were used more frequently in our study than in Scott's study except at the third grade level. whole, the frequency of usage of a given material in the two investigations was very different.

SUMMARY AND CONCLUSION

This paper deals with the use of manipulative materials in teaching mathematics in the primary grades. The writers considered two major questions: (1) What does research say about the value of using manipulatives in mathematics, and (2) What is the extent of classroom usage of selected manipulatives in the primary grades? The findings are as follows:

1. Research predominately favors the use of manipulatives, with strong support for the use of appropriate kinds of manipulatives for the beginning phases of learning new concepts in elementary mathematics.

2. A questionnaire survey of 75 teachers in kindergarten through grade three in 11 schools reported the following about the use of manipulatives:

(a) Of the four types of manipulatives included in this study, unifix cubes and Cuisenaire rods were the most frequently available to teachers at each school. However, fewer than one-half of the schools provided abacuses and base ten blocks for teachers to use in their mathematics programs.

(b) Teachers used unifix cubes more often than any other manipulative, and they used abacuses and base ten blocks less frequently than other aids.

(c) There was a wide variation in the use of manipulatives by teachers ranging in frequency from <u>often</u> to <u>no usage</u> of a given material.

(d) All 75 teachers reported they used manipulatives and that all pupils in the grades sampled manipulated materials at sometime during class instruction in mathematics.

RECOMMENDATIONS

In the light of the findings of this study, the writers arrived at the following recommendations:

1. Although research has verified the value of using manipulatives in teaching mathematics in the primary grades, we recommend further research to identify the best kind of manipulative aids to use for the development of specific mathematical concepts in these grades. We need to know, for example, if Cuisenaire rods can be used effectively to supplement any given textbook or should they be used as a complete Cuisenaire program.

2. We recommend that more research be conducted on the specific uses of unifix cubes. We know that they are

valuable for showing patterns with different colors and that they can help pupils visualize basic number facts. What is unclear is the extent to which the use of unifix cubes encourages pupils to develop the undesirable habit of counting to find answers. We question the extent to which the unifix cubes can be used to show base-ten concepts and we doubt if unifix cubes can be effectively used to develop place value concepts. We therefore recommend that base-ten blocks and abacuses be used for the development of these concepts.

3. We recommend that each school district identify the specific kinds of manipulative materials needed for the development of each major concept and skill at each grade level and make these kinds of materials available for the teachers to use with children in the beginning phases of instruction. Research has established the value of using manipulatives in teaching mathematics in the elementary school, but our study has shown that not all classrooms are stocked with an adequate supply of appropriate materials. For example, fewer than one-half of the classrooms were stocked with base-ten blocks and abacuses.

4. We further recommended that teachers in the primary grades frequently use appropriate manipulative materials for teaching mathematical concepts and skills. We strongly urge school districts to provide teachers with adequate instruction on how to use these manipulatives. This implies knowing when to use the materials and when their use should be discontinued.

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